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Placement of immediate dental implants in extraction sockets exhibiting the apical pathosis. A meta-analysis

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ABSTRACT

Objectives: It is commonly accepted that immediate implantation is the best option for patients since it shortens the time patients must wait for ultimate restoration and provides a predictable functional and aesthetic result. However, this approach is still controversial in patients with apical pathosis. The goal of this systematic review and meta-analysis was to determine the efficacy of immediate implant insertion in patients with apical pathosis.
Material and methods: Between 2000 and 2023, PRISMA-compliant keywords were used to search PubMed, MEDLINE, CENTRAL, and the Cochrane Library. All English-language clinical studies that met PICOS criteria were included in a manual search. The included studies' demographic profile and event data for immediate dental implantation success in patients with or without apical pathosis were meta-analyzed using RevMan. The implant survival rate was assessed using risk ratio of plaque index and bleeding index. Begg's test using MedCalc and RevMan risk of bias assessment assessed publication bias.
Results: A meta-analysis of 10 trials with 849 dental implantation patients found a substantial difference in initial implant placement success rates in infected sites. The pooled risk ratio for plaque index is 0.59 (95% CI: 0.36–0.96) with heterogeneity of $Tau^2 = 0.62$, $chi^2 = 109.69$, df = 11, $I^2 = 90\%$, z = 2.12, and $p < 0.05$. While, the pooled risk ratio for bleeding index is 0.77 (95% CI: 0.60 to 0.98) with $Tau^2 = 0.16$, $chi^2 = 103.67$, df = 11, $I^2 = 89\%$, z = 2.12, and $p < 0.05$. The pooled odds ratio of implant survival rate is 2.08 (95% CI: 1.56 to 1.79) with Tau^2 0.16; chi^2 52.43; df 9; I^2 83%; z 4.93 and $p < 0.05$. As evidenced by the funnel plot and statistically insignificant Begg's test p values of 0.45.
Conclusion: The placement of immediate implants in locations affected by apical pathosis is a clinically beneficial surgery, resulting in favorable aesthetic and functional outcomes for patients.

1. Introduction

The use of dental implants has become widely accepted recently because they can preserve natural tooth structure, reducing the requirement for traditional bridgework that would include modifying neighbouring teeth.[1,2] The most effective method for improving both the appearance and functionality in patients who have lost some or all of their teeth is by using dental implants.[3,4] Dental implantation can be carried out either immediately after tooth extraction or with a delay, during which a considerable amount of time elapses between the extraction and the implantation[5,6] (Fig. 1).

The practice of immediately inserting implants after removal teeth with persistent periapical disease has been a subject of attention in clinical practice. The existence of bacteria or substances that cause inflammation has the capacity to create a risk of contamination during the process of osseointegration of implants, therefore intensifying inflammation in these instances. Novaes et al. (2003)[7] argue that an immediate approach can be used in implant beds affected by chronic periapical or periodontal disease, as long as proper pre and post-operative protocols are followed. This argument is supported by other researchers.[8–10] Multiple studies have documented positive changes in bone structure near implants placed in areas untouched by acute infectious illnesses.[8–10]

Immediate dental implant implantation in infected areas is strongly

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associated with a much higher likelihood of implant failure compared to non-infected sites.[11] Studies have observed that placing a dental implant directly into an infected area can significantly raise the likelihood of implant failure.[12,13] Contrary to the research mentioned above, specific systematic reviews and meta-analyses[14,15] offer evidence suggesting similar rates of success and survival for rapid dental implant implantation in infected sites compared to non-infected sites. Similarly, recent academic research[16–19] has also documented similar rates of success for dental implants placed promptly in both peri-apical disease-free and peri-apical disease-affected areas.

In contrast, various authors[20–25] have documented that the immediate placement of implants following tooth extraction as a means of replacing teeth with periapical pathologies is a viable and effective treatment approach. These studies have found no drawbacks associated with this protocol and have deemed it an acceptable method for managing dental implants. In view of these inconsistent findings, this systematic review and meta-analysis was conducted to compare the efficacy of immediate implant placement in non-infected extraction sockets and infected extraction sockets with respect to implant function and survival in patients exhibiting apical pathosis.

2. Materials and methods

2.1. Search strategy

The current meta-analysis was performed after conducting an extensive search across many databases, such as Medline (through PubMed), Embase, Scopus, Cochrane library, and web of sciences. The study encompassed the time span from 2000 to 2022 and using specific search terms like "apical pathosis," "immediate implantation," "periodontally infected sites," "dental implantation," "systematic review," and "meta-analysis". "The identification of keywords based on the PICOs framework yielded consistent results in both the Medline and EMBASE databases. The Title (ti)-Abstract (abs)-keyword (key) field was employed in the process of scanning Scopus, using the specified keywords described before. The term "immediate dental implantation" was employed in the Cochrane database. The PICO framework was employed to provide specific criteria for selection. Within the given framework, the letter "P" is used to represent individuals with apical pathosis, "I" is employed to refer to the practice of immediate dental implantation in infected sites, "C" is utilized to designate delayed implantation, and "O" encompasses the outcomes "plaque index", "bleeding index" and "implant survival rate" for assessing the success rate of the implant. Furthermore, manual searches were also conducted in addition to database searches in order to identify relevant studies. The inclusion criteria stipulated that only scholarly articles published in the English language were taken into account. The procedure for incorporating papers into the study adhered to the principles outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Two researchers, referred to as AA and OM, did an extensive literature study in order to find relevant papers.

2.2. Inclusion and exclusion criteria

Relevant articles,[16–25] between the year 2000–2023, that includes patients with apical pathosis and requires implant placement; provides the required outcomes plaque index and bleeding index of apical pathosis patients with immediate dental implantation procedures were included in this study as per the PRISMA guidelines.[26] The inclusion criteria for this study were selecting only full-text papers, while excluding studies with insufficient data, studies that were not focused on the implantation method in periodontally diseased areas, and studies that were not published in the English language.

2.3. Selection process

Two reviewers, identified as AA and OM, independently assessed the methodological rigor of the research included in the analysis and computed the level of heterogeneity seen across the included experiments. Author KA was tasked with the responsibility of resolving any

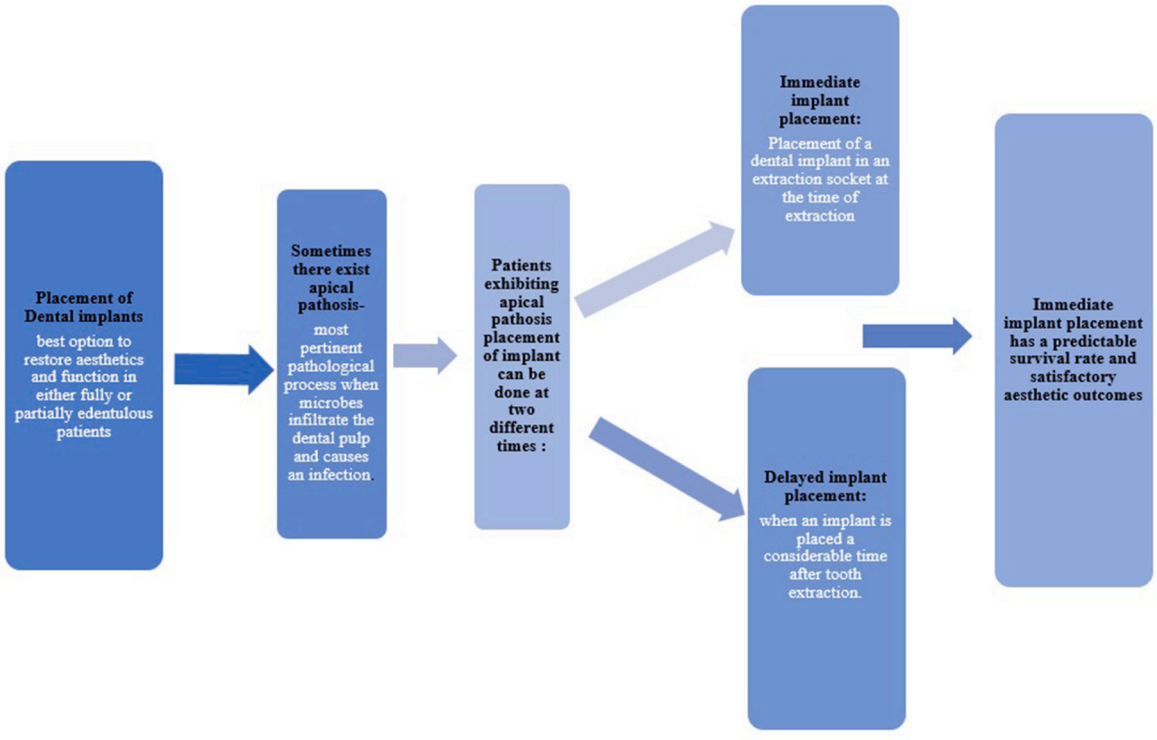

Fig. 1. Brief description of Dental implants.

issues that may arise between authors AA and OM.

Data Collection Process and Data Items.

The present study investigated several sources of heterogeneity, including the use of full-text publications rather than abstracts, differences in sample sizes and age groups, variations in the timing of implantation, distinct study outcomes, and comparisons with different control groups. The heterogeneity was examined by employing various statistical methods, including Deek's funnel plot, Cochran Q statistic, and I^2 index, in a random bivariate mode. The analysis was conducted using the RevMan software.

2.4. Study risk of bias assessment

Using a pre-established, standardized questionnaire, potential bias in the papers analyzed was evaluated. Using a Cochrane Collaboration instrument[27] published in the Cochrane Handbook (version 5.3), the risk of bias was evaluated. The instrument contained seven components: random sequence generation, concealment of allocations, blinding of personnel and participants, blinding of outcome assessors, selective reporting, incomplete outcome data, and other biases. Two separate evaluators, MA and AA, independently assessed the potential for bias. A third reviewer, designated as KA, arbitrated any lingering disagreements. The potential bias was ultimately evaluated and classified as "high risk," "low risk," or "unclear risk." The assessment of publication bias was conducted by the utilization of a funnel plot,[28] and the determination of statistical significance was accomplished by employing the Begg's test and MedCalc software.

2.5. Synthesis methods

The meta-analysis utilized the extracted data and employed statistical parameters such as the diagnostic odds ratio and relative risk, both accompanied by a 95% confidence interval. These parameters were calculated using the Mantel Haenszel method[29] with random bivariate effects. The software used for these calculations and the generation of forest plots was RevMan (Review Manager, RevMan, Version 5. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration. 2020). The assessment of heterogeneity in the studies included in the analysis was conducted using statistical measures such as the Tau^2 value, chi^2 value, I^2 value, and z value. A p-value less than 0.05 was deemed to be statistically significant. The diagnostic odds ratio was computed using the DerSimonian Lair approach.[30] In this study, a 2 X 2 table was constructed and a meta-analysis was conducted using the RevMan software. The diagnostic risk ratio and odds ratio were estimated using a pooled analysis,[31] and a 95% confidence interval was determined. Additionally, forest plots were created to visually represent the results. The assessment of publication bias in the included studies was conducted using Begg's test, and a funnel plot was created by graphing the logarithm of the risk ratio for each trial against its standard error. This analysis was performed using MedCalc software.[32]

3. Results

3.1. Results from the literature review

A comprehensive search was conducted using electronic databases, in accordance with the PICOS criteria, resulting in the identification of a total of 1167 studies.[33] A total of 183 papers were removed from the analysis based on a review of their titles and abstracts, leaving 984 data to be reviewed. Moreover, as a result of inadequate references and duplicative content, a total of 672 research were deemed ineligible and thus excluded from consideration. Consequently, only 312 papers were retained for the final screening process. Among the total of 312 research considered, a substantial number of 244 studies were deemed ineligible based on the established inclusion criteria. Consequently, the remaining 68 studies underwent a subsequent evaluation to determine their eligibility. The primary factors contributing to the deletion of certain elements were insufficient evidence and the utilization of improper criteria for constructing 2x2 tables during the assessment process. In this investigation, a meta-analysis was conducted using a total of 10 studies that satisfied the predefined inclusion criteria. These studies specifically examined the effects of rapid implant placement in patients with apical pathosis. The study flow, following the rules outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), is depicted in Fig. 2. The included ten studies, ranged from year 2000–2022, have total 849 patients that undertook dental implantation of different age groups. These patients exhibit either the periodontally infected sites or non-infected sockets and were chosen randomly for the immediate dental implantation procedure. The study involved the collection and statistical analysis of the success rates of implants in patients, both infected and non-infected.

Table 1 displays the demographic characteristics of the studies incorporated in this meta-analysis. The provided information encompasses the author's identity, publication year, intervention employed in the study, overall sample size, number of infected and non-infected participants, success rates seen in both the intervention and control groups, as well as the study's conclusion.

3.2. Assessment of risk of bias

The assessment of bias for the research included in the analysis is documented in Table 2 of the risk assessment of included studies. The examination of potential bias was conducted using the RevMan software. Among the 10 papers included in the analysis, it was determined that 5 studies exhibited a low risk of bias, while 3 studies were identified as having a moderate risk of bias. The modest level of risk was ascribed to the factors of allocation concealment and selective reporting. Nevertheless, it is worth noting that two studies displayed a significant likelihood of selection bias, as indicated by the risk of bias summary depicted in Fig. 3 and the risk of bias graph illustrated in Fig. 4.

4. Results of meta-analysis

The meta-analysis was conducted utilizing the RevMan program. The assessment of publication bias was conducted using the MedCalc program. The present meta-analysis exhibits a minimal likelihood of publication bias, as evidenced by the symmetrical inverted funnel plot (Fig. 5) and the non-significant p value of 0.45 obtained from Begg's test.[34]

The risk ratio of the studies included in the analysis was calculated utilizing the RevMan software. The study utilized the Mantel-Haenszel test with random effects to assess the efficacy of fast dental implant implantation in individuals with apical pathosis in comparison to those with non-infected sites.

4.1. Plaque index

Fig. 6 presents a forest plot[35] illustrating the risk ratios and variability of data pertaining to the plaque index. A pooled risk ratio (RR) value of 0.59 (95% confidence interval [CI] 0.36–0.96) was identified. A risk ratio value below 1 indicates a high likelihood of immediate implant implantation in the contaminated areas. The results demonstrate variability, as indicated by a Tau^2 value of 0.62, a chi^2 value of 109.69 with 11 degrees of freedom, an I^2 value of 90%, a z value of 2.12, and a p value less than 0.05.[36] The statistical significance of these data provides evidence to support the notion that immediate dental implants placed in periodontally diseased sites with apical pathosis exhibit a low plaque index and yield positive long-term functionality and excellent clinical outcomes.

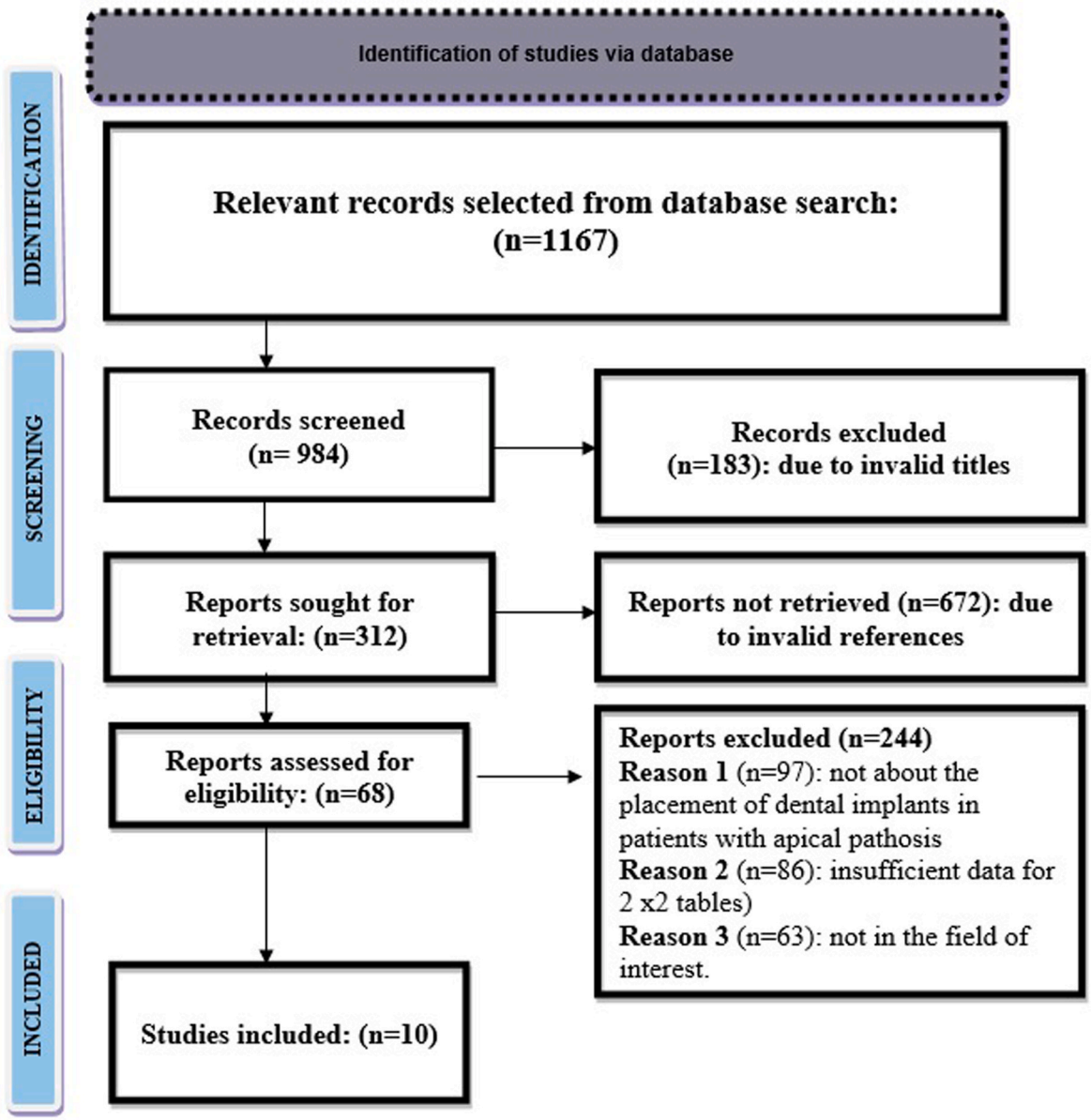

Fig. 2. PRISMA flowchart of selection of studies.

4.2. Bleeding index

The risk ratio of the bleeding index, together with its matching forest plot, is depicted in Fig. 7. The pooled risk ratio value was determined to be 0.77, with a 95% CI spanning from 0.60 to 0.98. The presence of heterogeneity in the outcome is shown by several statistical values: a Tau^2 value of 0.16, a chi^2 value of 103.67 with 11 degrees of freedom, an I^2 value of 89%, a z value of 2.12, and a p value less than 0.05. A risk ratio value less than 1 offers empirical support for the exclusion of the potential occurrence of bleeding risk in patients with periodontally diseased sites who undergo fast implant implantation. This discovery implies that the operation is deemed safe and is linked to positive outcomes in terms of both aesthetics and functionality. The heterogeneity value in meta-analysis serves to measure the extent of variability in study outcomes across the chosen studies and the populations or samples they represent. These findings are characterized by randomness and diversity.[37] The existence of considerable heterogeneity is substantiated by the heightened I2 index seen in both cases and the dispersion of effect sizes. The Z-value is the weighted average effect size and is considered to be statistically significant if the p-value is below 0.05. The p-value quantifies the probability of obtaining the observed level of significance. Furthermore, we have obtained z-values that are statistically significant and a p-value that is less than 0.05 for both calculations of the risk ratio.

4.3. Implant survival rate

Fig. 8 displays the odds ratio for the survival rate of implants in both infected sites, along with its corresponding forest plot. The overall odds ratio for the rate of implant survival is 2.08 (95% CI: 1.56 to 1.79) with a Tau^2 value of 0.16. The chi-square statistic is computed as 52.43, with 9 degrees of freedom. The result is an I^2 value of 83%. The z-score is 4.93, signifying a divergence from the mean. The p-value is determined to be below 0.05, indicating statistical significance. An odds ratio larger than 1 indicates a high probability of successful implantation when immediately placing the implant in infected sites.

This study provides confirmation, based on statistically significant findings derived from multiple meta-analyses ($p < 0.05$), that the practice of rapid dental implantation in patients with apical pathosis has

Table 1
Brief characteristics of the included studies.

Study ID and year	Journal of publication	Intervention	Sample size	Immediate Implant in patients with periapical lesion	Success rate	Immediate Implant in control patients with no periapical lesion	Success rate	Conclusion
Lindeboom et al 2006[16]	Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology	Evaluation of success rate of immediate placement of implants in periapical infected sites	48	23	92%	25	100%	Immediate insertion of dental implants may be recommended in cases with chronic periapical lesions.
Siegenthaler et al 2007[17]	Clinical oral implants research	Replacement of teeth with periapical pathology via the immediate implants	65	30	100%	33	100%	In implants with primary stability, rapid implant placement at extraction sockets with periapical disease did not increase problems and provides acceptable tissue integration. Hence, Implant implantation in such sites is feasible.
Fabbro et al 2009[18]	Journal of Oral and maxillofacial surgery	Study of effects of immediate implant placement into fresh extraction sites with chronic periapical pathologies	120	59	98.4%	61	100%	When administered in conjunction with plasma-rich growth factors, an immediate implant implantation procedure can be regarded as a safe, effective, and predictable treatment option for the rehabilitation of newly infected sockets following extraction.
Crespi et al 2010[19]	Journal of periodontology	Comparison of Immediate placement of dental implants in periodontally infected and non-infected sites	275	78	98.9%	197	100%	When dental implants were inserted and placed immediately into periodontally diseased sockets, there were no significant distinctions from implants positioned in uninfected sites.
Truninger et al 2011 [20]	Clinical oral implants research	Evaluation of the clinical and radiological outcome of implants immediately placed implants in the sockets with periapical pathology after 3 years	29	13	100%	16	100%	Immediate implant implantation into sites with periapical diseases can last at least 3 years without clinical or radiological disadvantages compared to healthy sockets.
Jung et al 2013[21]	Clinical oral implants research	Evaluation of the clinical radiological and aesthetic outcomes of implants immediately placed in sockets exhibiting periapical pathology after 5 years	27	12	100%	15	100%	Implants implanted immediately following tooth extraction can replace teeth with periapical diseases without clinical, aesthetical, or radiological drawbacks against implants inserted into healthy sockets.
Malchiodi et al 2016[22]	The International journal of Oral and maxillofacial implants	Assessment of Primary and Secondary Stability of Implants in post-extraction and healed Sites:	38	15	100%	20	100%	The implant stability quotient (ISQ) at loading remains unaffected by the timing of implantation (immediate or delayed) due to the achievement of effective osseointegration.
Eid et al 2020[23]	Al-Azhar Assiut Dental Journal	Effect of immediate Implant placement on teeth Exhibiting Periapical Pathosis	24	11	100%	13	100%	For teeth with periapical pathosis, immediate implant insertion in conjunction with adhesive bone and enhanced fibrin membrane is an effective treatment.
Camara et al 2020[24]	Medicina Oral Patologia Oral y Cirugia Bucal	Evaluation of success rate of placement of Immediate post-extraction implants in acute periapical infected sites	97	46	100%	50	100%	At sites with acute periapical pathology, immediate prosthetic provisionalization and implant implantation can be an effective treatment modality for at least one year.
Kakar et al 2020[25]	Journal of Lasers in Medicinal sciences	Success rate of immediate implant Placement in Infected Sockets	126	61	95.45%	65	100%	Immediate implants implanted in previously infected areas had a similar survival rate to non-infected sites.

favorable results in terms of effectiveness, safety, and successful restoration, ultimately leading to positive functional outcomes.

5. Discussion

Immediate implant insertion is often recommended when tooth extraction is necessary as a result of trauma, endodontic lesion, root fracture, root resorption, root perforation, an unfavourable crown-to-

Table 2
Risk assessment for included studies.

Study ID and Year	Lindeboom et al., 2006[16]	Siegenthaler et al., 2007[17]	Fabbro et al., 2009[18]	Crespi et al., 2010[19]	Truninger et al., 2011[20]	Jung et al., 2013[21]	Malchiodi et al., 2016[22]	Eid et al. 2020[23]	Camara et al., 2020[24]	Kakar et al., 2020[25]
Was a consecutive or random sample of patients enrolled?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did the study avoid inappropriate exclusions	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did all patients receive the same reference standard	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were all patients included in the analysis	N	N	N	N	N	N	N	N	N	N
Was the sample frame appropriate to address the target population?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were study participants sampled in an appropriate way?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were the study subjects and the setting described in detail?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were valid methods used for the identification of the condition?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the condition measured in a standard, reliable way for all participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

root ratio (not attributable to periodontal loss), and when the alveolar bone walls are conserved. The term "immediate insertion of dental implants" pertains to the surgical procedure wherein dental implants are promptly placed into the jawbone subsequent to the extraction of a tooth. Optimization of the implantation process and improvement of the implant's likelihood of successful osseointegration can be attained through the placement of the implant's root in a recently vacated site.[38] In modern times, dental implant surgeries have grown more common. These surgeries can be categorized into four different sorts dependent on when the implant is installed. Dental implant surgeries can be classified into four categories according to the timing of tooth extraction. Surgical procedures of type 1 are carried out immediately after the removal of the tooth. Type 2 surgeries are performed within a period of four to eight weeks after the extraction. Type 3 surgeries are delayed and conducted between 12 and 16 weeks following the extraction. Type 4 surgeries are performed more than 16 weeks after the tooth extraction.[39,40]

Nevertheless, the approach of immediately placing the implant has received endorsement from numerous research, especially in instances where just one implant is implicated. This phenomenon occurs because it has the ability to decrease the overall duration of therapy and minimize patient morbidity. Esposito et al. (2010)[41] and Rodrigo et al. (2012)[42] provided evidence that the survival rates of dental implants placed immediately were comparable to those of implants placed at a later time or using traditional methods. However, the clinical studies conducted by Vignoletti et al., in 2009,[43] Sanz et al., in 2017,[44] and Cosyn et al., in 2019[45] have shown that rapid implant placement does not hinder the natural bone remodeling process that occurs during the development of the peri-implant soft-tissue complex. Consequently, the production of large implant threads occurs, which makes it easier for bacteria to colonize the implant and ultimately leads to the development of periodontal problems.

The aim of this study was to perform a systematic review and meta-analysis of the selected RCTs[16–25] to investigate the contradictory perspectives regarding the use of an immediate implant placement method in patients with apical pathosis. The main findings of the included studies are as follows: Lindeboom et al.[16] assess the clinical efficacy of implant insertion in chronic periapical infected areas in their randomized controlled trial (RCT) involving 50 patients. Following randomization, 25 Frialit-2 Synchro implants were immediately placed (IP) following tooth extraction, whereas another 25 Frialit-2 Synchro implants were inserted after a 3-month period of healing (DP). The study assessed the longevity of the implants, the average Implant Stability Quotient (ISQ) values, the appearance of the gums, the amount of bone loss seen on X-rays, and the microbiological properties of periapical lesions for both groups. The study revealed a 92% survival rate for IP implants compared to a 100% survival rate for DP implants. The mean ISQ, gingival aesthetics, radiographic bone resorption, and periapical cultures did not show any significant differences between the IP and DP implants. Therefore, they suggested the insertion of an immediate implant in cases of chronic periapical lesions. In their RCT involving 17 patients, Siegenthaler et al.[17] investigate if immediate implantation, when carried out at the extraction sockets of teeth demonstrating periapical pathology compared with teeth not showing periapical pathology, results in more biological complications. The clinical and radiographic parameters were assessed at the time of implant placement (baseline) and at 12 months beyond. One year after implantation, they found that 29 implants that were still in situ had a 100% survival rate. When comparing the test and control groups, clinical and radiographic variations between the 12-month and baseline revealed no statistically significant differences for any of the measures evaluated. They found that in cases where primary stability was attained, prompt implant placement at extraction sockets with periapical pathology did not result in a higher rate of complications and produced a tissue integration type of implant that was equally beneficial for both groups. Therefore, it is possible to successfully place implants into such sites for both groups' implants. Therefore, implant implantation into such sites can be accomplished with success.

In their study, Fabbro et al.[18] assessed the clinical outcome of implants placed immediately into fresh extraction sockets of teeth with chronic periapical pathologic findings. To achieve this, they incorporated plasma rich in growth factors (PRGFs) as an adjunct during the surgical procedure. The present study comprised 30 partially edentulous patients who had chronic periapical lesions. After one year of function, a total of 61 transmucosal implants were inserted into the socket following

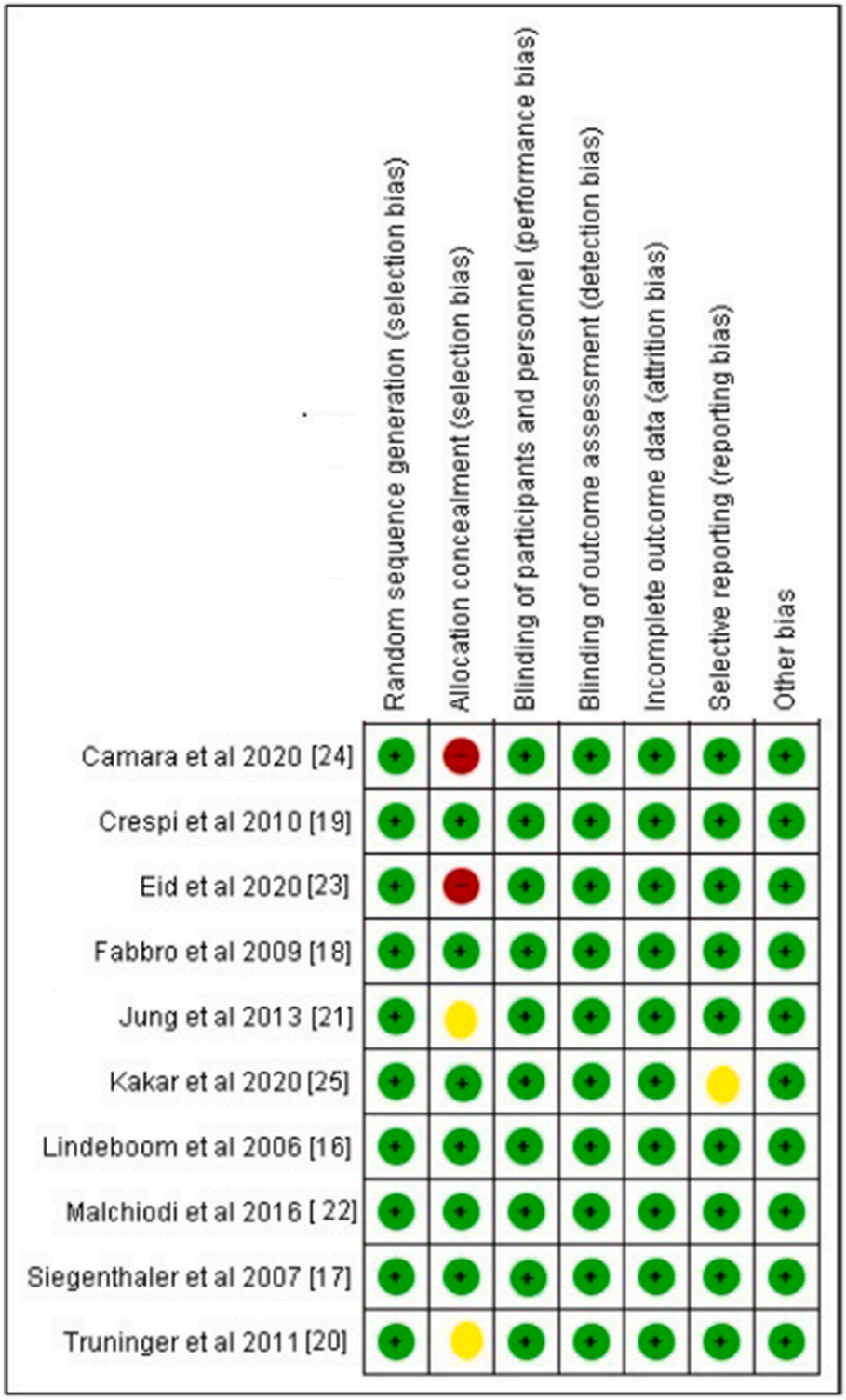

Fig. 3. Risk of Bias summary.

careful debridement and insertion of PRGF promptly following extraction. After one year of operation, the implants' success and survival, as well as radiographic bone loss, were assessed. Regarding the 61 implants, there were no further complications documented. At one year of function, the overall efficacy and survival rate of implants was 98.4%. Every single prosthesis was effective. In regards to phonetics, esthetics, and mastication function, every patient expressed complete satisfaction. In conclusion, they concluded that the combination of PRGFs and an immediate implant placement procedure for the rehabilitation of newly extracted infected cavities can be regarded as a safe, effective, and reliable treatment option.

In their study of 37 patients, Crespi et al.[19] assess the results of immediate loading of implants in replacing teeth with and without chronic periodontal diseases at 4 years of follow-up. A total of 275 implants—197 in periodontally infected sites [IG] and 78 in non-infected sites were positioned and loaded right away in extraction sockets. They assessed clinical parameters (plaque buildup and bleeding index) and marginal bone levels at baseline, 12-, 24-, and 48-months

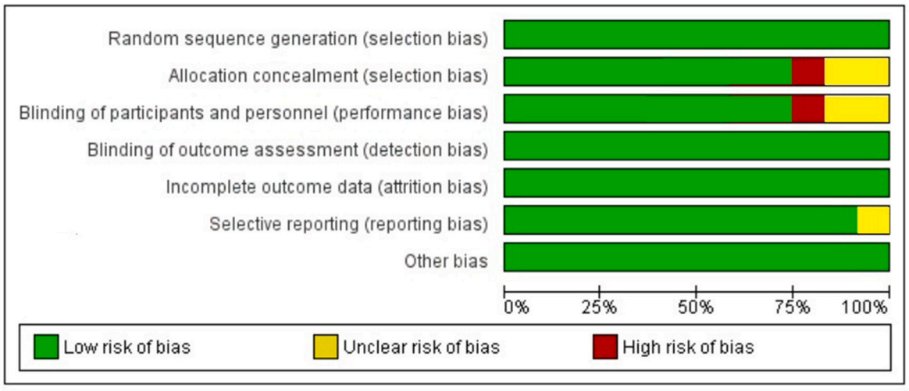

Fig. 4. Risk of bias graph.

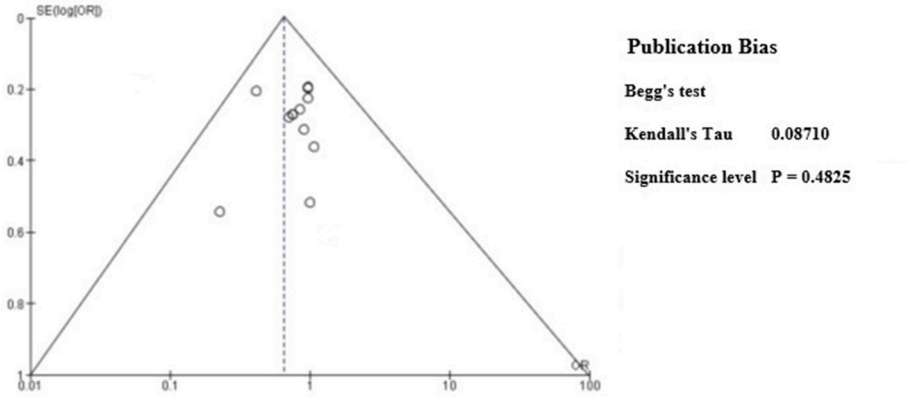

Fig. 5. Funnel Plot for publication bias.

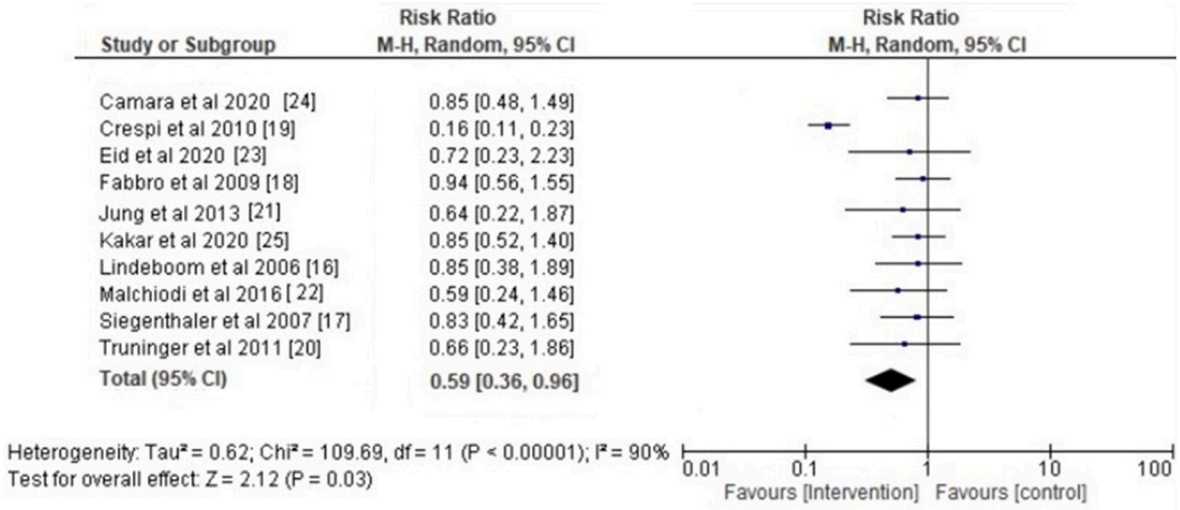

Fig. 6. Forest plot for primary outcome: Risk ratio of plaque index.

following implant implantation. Following up for 48 months, they discovered that the NG had a 100% survival rate, whereas the IG had a 98.9% survival rate due to the loss of two implants one month after implantation. The IG and NG had marginal bone levels of 0.79±0.38 mm and 0.78±0.38 mm, respectively; the IG and NG had plaque buildup of 0.72±0.41 and 0.71±0.38, respectively; the IG and NG had bleeding index values of 0.78±0.23 and 0.75±0.39, respectively. Between time and between time points, no statistically significant changes were seen between the IG and NG. When dental implants were inserted and immediately loaded into periodontally infected sockets, they found that there were no appreciable variations between them and implants inserted into uninfected locations. Truninger et al.[20] conducted an RCT of 29 patients with immediately placed implants in sockets with or without periapical pathology 3 years after implant placement. They measured clinical (full-mouth bleeding score, full-mouth plaque score, clinical attachment level measurements, and width of keratinized

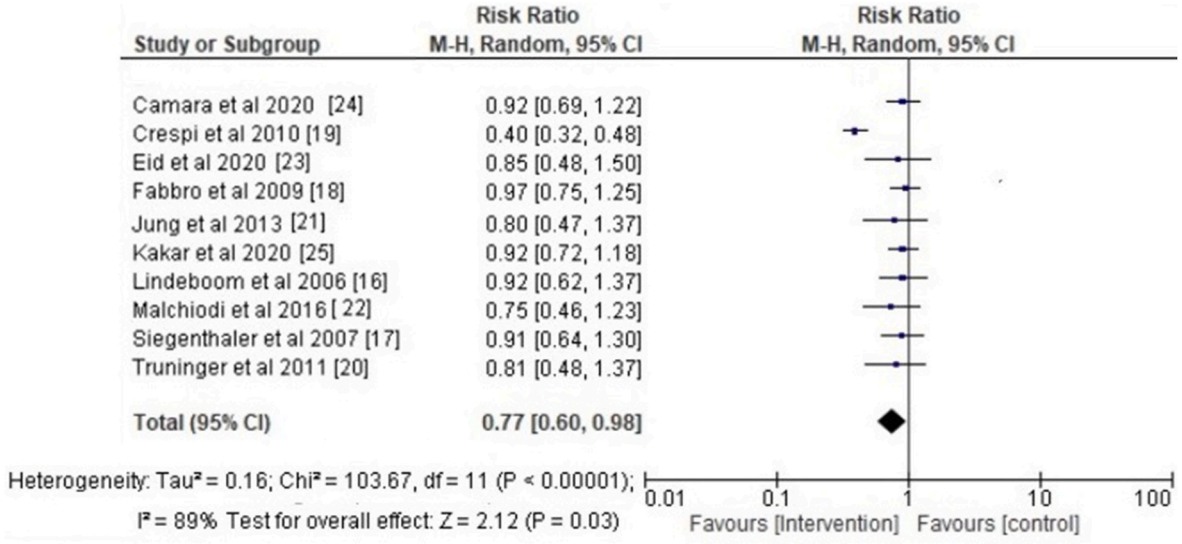

Fig. 7. Forest plot for primary outcome: Risk ratio of bleeding index.

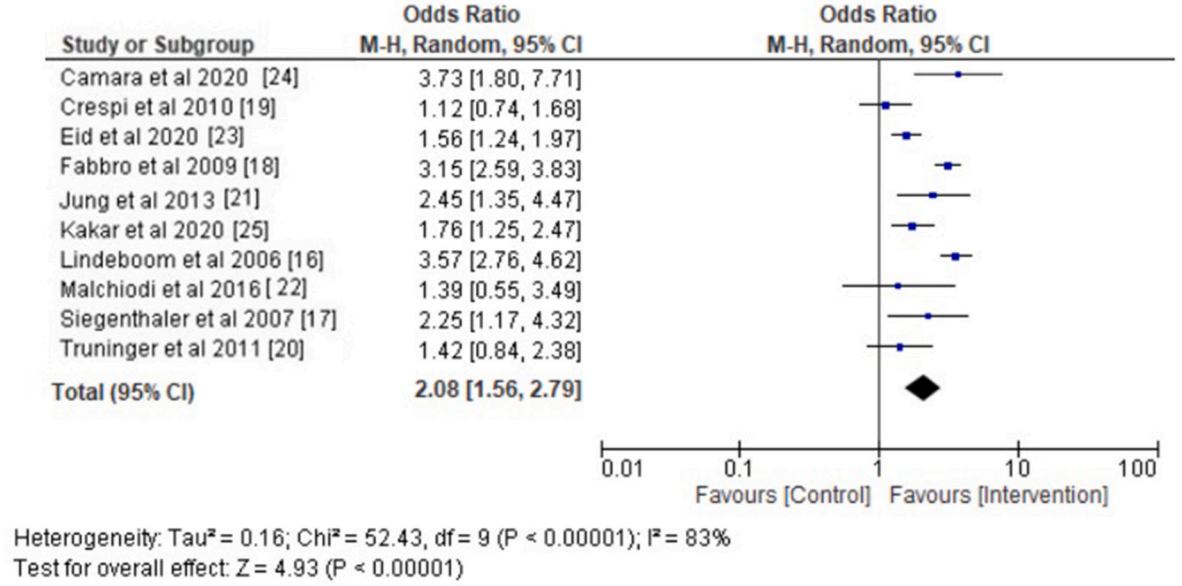

Fig. 8. Forest plot for primary outcome: Implant survival rate.

mucosa buccally of the implant) and radiological parameters. In 3 years, all 29 implants survived 100%. Two-sample *t*-test demonstrated no statistical difference between the test and control groups at 3 years in clinical and radiological data. After cautious surgical debridement of the extraction socket, immediate placement of implants into sites with periapical pathologies may represent a successful treatment modality for at least 3 years with no clinical or radiological disadvantages compared to healthy sockets.

In a study of 27 patients, Jung et al.[21] compared the clinical, aesthetic, and radiological outcome of immediately placed implants in sockets with or without periapical pathology five years after placement. Clinical, aesthetical, and radiological parameters were assessed. They found that, after five years, the implant survival rate was 100% for all 27 implants, and there was no statistically significant difference between the two groups in terms of primary outcome. They came to the conclusion that replacing teeth with periapical pathologies with implants placed immediately after tooth extraction can be a successful treatment modality with no drawbacks in terms of clinical, aesthetic, and radiological outcomes. Malchiodi et al.[22] examined the relationships between insertion torque, implant stability quotient (ISQ), and crestal bone loss (CBL) in 40 individuals randomly assigned to two groups with implant placed immediately or 12 weeks after extraction at premolar or molar sites. Insertion torque and ISQ scores at loading and insertion were recorded for all implants. Patients were monitored for 12 months. Both groups had 100% implant success. ISQ during insertion and loading were identical. In conclusion, implant placement time (immediate or delayed) may alter association between insertion torque and ISQ during insertion and loading. Due of effective osseointegration, insertion torque affects ISQ at insertion but not loading. Due to post extraction bone remodeling, delayed and post extraction implants show identical ISQ at insertion and loading but differing CBL after 12 months. Osteo-integration ensures implant stability quotient (ISQ) during loading regardless of implantation date.

In their study, Eid et al.[23] assess the clinical, radiographic, and

resonance frequency analysis outcomes of immediate implant placement combined with sticky bone and enriched fibrin membrane in 13 patients with teeth exhibiting periapical pathosis that required extraction. The alterations in implant stability and bone density measurements were assessed using the ostel device and cone beam computed tomography (CBCT) immediately after the procedure and again after a 6-month healing period. The study concluded that utilizing immediate implant implantation in conjunction with adhesive bone and enhanced fibrin membrane is an effective method for treating teeth with periapical pathosis. Camara et al.[24] compared the clinical and radiological outcomes of immediately placed implants with immediate prosthetic provisionalization in sockets with or without acute periapical pathology in 100 patients over one year. Clinical and radiological characteristics (distance from implant shoulder to first point of bone-to-implant contact [IS-BIC]) were examined. After one-year, clinical metrics did not change between study and control groups ($p > 0.05$). IS-BIC showed no significant differences between study group (0.35 ± 0.51 mm) and control group (0.15 ± 0.87 mm) ($p = 0.160$). None of 50 immediate implant radiographs in sockets with periapical disease showed retrograde peri-implantitis. They found that initial implant implantation and prosthetic provisionalization at locations with acute periapical disease can last at least a year. Immediate implant implantation and prosthetic provisionalization may treat acute periapical disease for at least one year. Kakar et al.[25] examined the clinical outcomes of immediate dental implant placement in infected extraction sockets using a standardized protocol that included (a) laser decontamination before implant insertion and (b) in situ hardening alloplastic bone graft substitute to fill the gap between the implant surface and the labial plate of bone in 68 patients. Implant implantation was followed by 136 ± 73 days (mean $\pm$ SD; range: 37–400 days) of loading. The described procedure saved 105 of 110 implants (95.45%) implanted promptly in contaminated locations following prosthetic loading. They determined that rapid implant insertion in previously infected locations employing the methods demonstrates a similar survival percentage for infected and non-infected sites.

Our meta-analysis results of the 10 included studies[16–25] indicated that the pooled risk ratio for plaque index is 0.59, with a 95% confidence interval [CI] of 0.36–0.96. Observation of heterogeneity was indicated by the following statistical values: $Tau^2 = 0.62$, $chi^2 = 109.69$, df = 11, $I^2 = 90\%$, $z = 2.12$, and $p < 0.05$. The bleeding index has a pooled risk ratio of 0.77 (95% CI: 0.60 to 0.98) and a Tau^2 value of 0.16. The chi-square statistic is calculated to be 103.67, with 11 degrees of freedom. This leads to an I^2 value of 89%. The z-score has a value of 2.12, indicating a deviation from the mean. The p-value is found to be less than 0.05, suggesting statistical significance. The pooled odds ratio of implant survival rate is 2.08 (95% CI: 1.56 to 1.79) and a Tau^2 value of 0.16. The chi-square statistic is calculated to be 52.43, with 9 degrees of freedom. This leads to an I^2 value of 83%. The z-score has a value of 4.93, indicating a deviation from the mean. The p-value is found to be less than 0.05, suggesting statistical significance.

Patients who received immediate implantation had a significant rate of successful implantation, without any recorded cases of negative outcomes such as patient discomfort, implant movement, or swelling. Hence, the findings of this study offer support for the adoption of immediate dental implant placement in individuals with apical pathosis.

6. Limitations

The present investigation is subject to certain limitations. To begin with, the exclusive reliance on English language publications for the paper selection procedure could potentially result in the introduction of bias. Furthermore, there is a scarcity of research that has examined the clinical parameters, classification of sockets, and etiology of the condition, all of which may marginally influence the outcomes. To augment the lucidity of the evaluation, it might be advantageous to integrate data from supplementary relevant studies that expound upon the suitable documentation concerning the morphology of the fresh-socket site and the origin of pathology. The primary emphasis of this study is on the survival rates of implants as a dependable indicator of success, albeit with an understanding of the possibility of variability. Applying analogous selection criteria to different RCTS was exceedingly challenging on account of their diverse characteristics; for instance, a considerable number of cases exhibited risk factors at the site of extraction, including the absence or thinness of buccal bone. Additionally, contemporary implantology is distinguished by consistently high rates of survival. On account of this, it is essential to consider additional factors such as the aesthetics of the peri-implant soft tissues, the characteristics of the bone, and the dimensions of the soft tissues surrounding the implant in order to achieve a desirable aesthetic outcome. However, it is crucial to recognize that additional variables, such as the aesthetic quality of the soft tissues enveloping the implant and the classification of recently extracted receptacles, might be incorporated in order to enhance the overall outcomes.

7. Conclusions

In patients with periodontal disease or apical pathosis, immediate implant placement is a viable option for replacing missing teeth and preserving their long-term functionality, according to the current meta-analysis, which was based on statistically significant meta-analysis results ($p < 0.05$) of the primary study outcomes: plaque index, bleeding index, and implant survival rate. To accomplish optimal wound healing, good implantation settling, and positive functional effects, it is highly recommended to produce an astringent environment and use antiseptic therapies. Nevertheless, large sample size randomized controlled clinical trials are necessary to reach a firm conclusion regarding the treatment's safety and efficacy.

Ethics approval and consent to participate

Not applicable as the study is totally based on the published literature.

Consent for publication

Not Applicable.

Availability of data and material

Upon reasonable request, the corresponding author will provide access to the requested information.

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Authors' contributions

AA: Concept and designed the study, OM and KA: analyzed data and drafting of the manuscript; MA and AN: Collected the data and helped in data analysis; AH: Proofreading and final editing along with guarantor of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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